Sustainability and traceability of lithium supply from geothermal waters

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Project Highlights:

- Generate new insights as to how lithium can be tracked and traced from its geological source through to processed products.
- Establish new, sustainable methods of lithium extraction from geothermal waters using battery materials as molecular sieves.
- Work with Cornish Lithium, a world-leader in sustainable and environmentally responsible lithium extraction, to diversify methods of lithium production and benefit the battery industry.

Overview:

Finding new and sustainable sources of lithium is essential for enabling the transition to the green energy systems that are needed for decarbonisation. Lithium is a key component of batteries used for electric vehicles and stationary power storage, and demand for lithium is forecast to triple by 2030.

It is now recognised that warm groundwaters, or geothermal waters, circulating through the Earth's crust can contain high amounts of lithium. Geothermal waters have not been widely used as a lithium resource to date, but they may have many benefits, for example being easier to extract with a lower environmental footprint. The aims of this project are three-fold: (1) To understand and quantify the processes that lead to lithium enrichment in geothermal waters. (2) To establish new, sustainable methods for extracting lithium from geothermal waters. (3) To identify, track and trace lithium as it moves along the supply chain from geothermal source to processed product by synthesizing the results of (1) and (2). The project will be carried out in collaboration with Cornish Lithium, who will provide access to unique, Li-rich geothermal waters circulating within the granite rocks that underlie Cornwall in the UK.

While chemical analyses suggest that Cornish geothermal waters are the product of reactions between meteoric waters and granitic rocks, their lithium content is variable, pointing to different flow paths, and possibly different lithium sources. This project will use novel analysis of lithium isotopes (^{6}Li and ^{7}Li) to constrain the origins of these high lithium waters (Fries et al., 2019), better predict where they can be found and enable lithium to be tracked and traced as it moves through the Earth system.

Finding sustainable techniques for extracting lithium from geothermal waters remains an on-going challenge. A particularly advantageous method involves the use of battery materials as molecular sieves, which trigger ion-exchange reactions in which the extraction of lithium is achieved by releasing sodium, which has low environmental impact. However, degradation of the battery material under geothermal conditions could lead to contamination issues, so a key focus of this project will be assessing the suitability of alternative materials and determining the environmental fate of degradation products. By fingerprinting the isotopic composition of processed lithium that has passed through the molecular sieve, the project will validate lithium traceability through the whole supply chain, from geothermal waters to processed product.

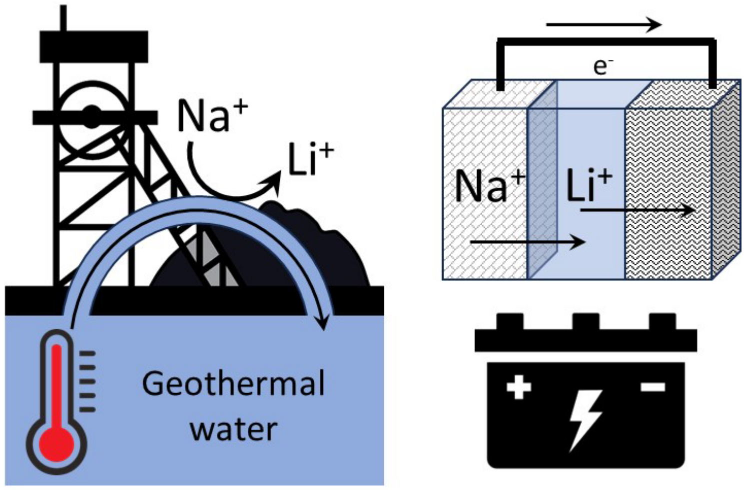

Figure 1: Sketch showing how the addition of sodium to geothermal waters contained within a battery leads to extraction of lithium when the battery is turned on.

Methodology:

Geothermal waters will be collected by the postgraduate researcher from boreholes in Cornwall in collaboration with Cornish Lithium. The researcher will also collect samples of potential lithium source materials, including rocks and meteoric waters.

The researcher will extract lithium from the geothermal waters following methods already successfully demonstrated (Perez-Rodriguez et al., 2022) and evaluate the efficacy of different approaches by monitoring the change in the chemical and lithium isotopic composition of the geothermal water. The environmental effects of the extraction process will also be considered.

The composition of the geothermal waters, lithium source materials, and the products of lithium extraction will be determined by highly sensitive chemical and state-of-the-art stable isotope analysis. The latter provides unique information not only on the sources of lithium, but also the processes that control lithium behaviour in the natural environment and industrial processes, and the ability to identify, track and trace lithium as it moves from its source to the next step in the supply chain.

Possible Timeline

Year 1: Collection of geothermal waters and lithium source materials. Identification and acquisition of best-in-class battery materials with high environmental compatibility for extraction of lithium from geothermal waters.

Year 2: Analysis of chemical and isotopic composition of geothermal waters and lithium source materials. Investigation of the long-term effects and isotopic fingerprint of lithium extraction using the selected battery materials with geothermal waters from Cornwall.

Year 3: Incorporation of Li isotope data to refine models for the formation of Li-bearing geothermal waters. Evaluation of battery materials for sustainable lithium production. Assessment of the potential for using isotopes to track lithium sourced from geothermal waters as it moves to the next step of the supply chain, using Cornwall as a case study.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

Partners and collaboration (including CASE):

Analyses of the geothermal waters and lithium source materials and experimental work on lithium extraction will be carried out at the University of Southampton. TARGET Partner Prof. Frances Wall from the University of Exeter will provide expertise on environmental management and responsible resource extraction as well as the regional development of georesources in Cornwall. CASE Partner Cornish Lithium will provide access to samples, support the researcher in the field and provide opportunities for work experience. They will also provide strategic advice on scaling up extraction techniques.

Further reading:

Fries D.M., James R.H., Dessert C., Bouchez, J., Beaumais A., Pearce C.R. (2019) The response of Li and Mg isotopes to rain events in a highly weathered catchment. Chemical Geology 519, 68-82. Doi: 10.1016/j.chemgeo.2019.04.023.

Perez-Rodriguez S., Fitch S., Bartlett P.N., Garcia-Araez N. (2022) $LiFePO_4$ battery material for the production of lithium from brines: Effect of brine composition and benefits of dilution. ChemSusChem 15(1), e202102182. Doi: 10.1002/cssc.202102182.

https://cornishlithium.com/

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply. For informal enquiries about this project, please contact Prof. Rachael James (R.H.James@soton.ac.uk). More information on postgraduate research at the University of Southampton can be found here.